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Physical Behavior of a.PP/LDPE Blends under Different Conditions

Balkees M. Al-Dabbagh

Department of Applied Science, University of Technology, Baghdad, Iraq

balkees1957@yahoo.com

Hanaa J. Khadim

Material Engineering Collage, Polymer Engineering Department, University Of Babylon/ Iraq/

hanajawad21@yahoo.com

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Abstract

The aim of this work was to make LDPE /a.PP blends for economically attractive by (10/90, 20:80, 30:70, &50:50 w/w) ratios via injection molding carried out under 180 ° C injection temperatures and to evaluate their mechanical properties including :(Density, Tensile Strength, Elongate to Break, Impact Strength, Bending Modulus,& Young's Modulus . we notice that the blend behavior dependent on its composition, and injection temperature .

Results show there are an increasing of impact strength and bending modulus with increasing of (LDPE) contain and the highest value of these properties were at (50:50) weight ratio, while it has the highest Young's modulus at (30:70) wt%. 180 ° C as injection temperature leads to translate the mechanical behavior from ductile to stiff behavior. DSC curves show that the blends is immiscibility , also thermal degradation was decreased with increasing of LDPE to (50%).Also the Melt flow index decreased from (5.04)-(4.01) (g/10 min) with increasing of LDPE from (30%) to (50%).

Key words: Immiscible blends, PP/LDPE blend, Physical properties, LDPE; PP; Blends; Tensile and impact properties, Bending, Density of blends.

1. Introduction:

As the economy achieves global status, many factors regarding the competitiveness of a nation come under investigation. More recently, together with important areas such as technology advancement and technology transfer, issues related to sustainable development and environment preservation are receiving increasing attention from the world community. [1]

Mixing of the polymers especially polyolefins leads to production of materials with positive properties omitting more expensive stages of the new polymer synthesis. [2]

One of the most extensively studied polyolefins are polyethylene and isotactic polypropylene. Many papers are devoted to investigations of the polyethylene-polypropylene blends [3].

Because of their large usage, polyolfins are likely to be major components of any source of scrap plastics, which might be candidate for this scheme of reuse. [4]

When polypropylene is added to the polyethylene, there is a significant reduction in impact strength, with partial sample fracture for the 25%LDPE content blend. Further PP addition makes the blend behavior change from ductile to brittle. [5]

Blends of polypropylene (PP) and polyethylene (PE) have become a subject of great economic and research interest because of the need to improve the processing and properties of PP as an engineering plastic due to its relatively reduction of impact strength especially at low temperature and week environmental stress cracking resistance. Blends of PP with linear low-density polyethylene (LDPE), have been reported to be miscible, partially miscible or immiscible. [6]

The low interfacial adhesion between the phases is responsible for a decrease in mechanical properties especially related to its morphology, including impact strength; strain at break and ductile to brittle transition. According to Shanks [7]

The incompatibility between LDPE and PP has already been reported by various authors [8], following microscopy and calorimetric studies. In LDPE rich blends, a heterogeneous PP dispersion in the LDPE matrix produces two phases in the melt.

, the immiscibility between the phases makes the rule of mixtures ineffective in predicting some properties of interest.

The Impact strength and fracture toughness are often the deciding factor in material selection because impact test measures the ability of polymer to withstand the load imposed upon being struck by an object at high velocity, thus it is a measure of energy required to propagate a crack cross the specimen, therefore the impact properties of these samples are especially important.

Impact strength was measured by eq. (1): [9]

$$I.S = \frac{U\ (J)}{A} \qquad \ldots (1)$$

Where I.S: impact strength
U: energy of fracture
A: cross section area of the sample
Bending elasticity modulus was measured by:

2. Materials and methods

Low Density polyethylene (H301-Braskem) and atactic polypropylene (BC 818-Braskem) were used. The specific gravity of the PP is 0.905 and that of the LDPE is 0.918 g/cm3, with melt flow index of 10.0 and 7.5 g/10 min, respectively. Blends of (LDPE:PP) were processed in an injection-molding machine with various LDPE/ PP weight contents, namely PE10, PE20, PE30,PE50, as in table 1.

Table 1. Blended that prepared at this search

Sample name	LDPE content	PP. content
PE10	10%	90
PE20	20%	80%
PE30	30%	70%
PE50	50%	50%

These blends was processed at 180 ^{o} C injection temperature. Samples were prepared for the tensile test in accordance with ASTM D638-87 procedure, computerized universal testing machine model (WDW-50E). Jinan Shijin Group Company. The test was conducted at a constant strain rate of the order 10 mm/min at room temperature. Tensile stress was a.PP lied till the failure of the sample and stress - strain curve was obtained .Each sample was tested for 3 times and average results have been reported. Impact test is performed at room temperature according to ASTM ISO 179, Izod charpy tension impact test measurement test machines, XJU-22 Time group Inc. Bending modulus also measured, this test is performed according to ASTM D790-78 at room temperature. The density of samples was measured according to Archimedes' law.

3. Results and discussion

3.1 Density of blends

Fig (1) shows the relationship between the density of samples and the PE content, we notice that the density of blends decreasing with the first contents of LDPE (10% & 20%) , this is because there is an voids between the molecules of two compounds of blends because immiscibility, while the density of blends increasing with increasing of LDPE contents, this is because the sample of blend follows the rule of mixture because immiscibility. [10]

3.2 Bending test:

Fig 2. Shows the effect of LDPE % ratio on bending modulus of blends (LDPE:PP), we notice that the decreases with increasing the LDPE content at (10-20)% range while it increases with (50)% content , because there are an increasing of hardness and constant tensile strength. This is because that disentanglement or rupture of tie-molecules was the dominant molecular mechanism in environmental stress cracking of polypropylene and in slow crack growth. The tie-molecules have also been identified as exhibiting similar mechanisms in impact and yield strengths. Thus, tie-molecules are important to all strength properties of polypropylene. Hence, the increasing concentrations of LLDPE introduced tie-molecules into the polymer blend [11]

3.3 Shore D Hardness

Fig 3. Show the effect of LDPE content on Shore D hardness we show it increases with 10% & 20% LDPE content while it decreases with increasing of LDPE content at (30-50)% , this is because the translating behavior of blend from ductile to brittle at 180 o C injection temperature leads to increasing of hardness, Furthermore the nature of PP which is more stiff than LDPE then increasing of LDPE content leads to decreasing of Shore hardness of blends.[12]

3.4 Tensile Test

3.4.1 Young's Modulus of Elasticity

Figure 4. shows the results of tensile tests for the Young's modulus of LDPE : a.PP blends , we notice that the E modulus increases with increasing of LDPE content because there are an increasing of hardness because it translate to hard state at 180 o C but it decreases with 50% LDPE content.[12]

Increasing of LDPE ratio up to (50)% ratio , Young's modulus was decreased to (0.03 GPa) suggesting agreement with the rule of mixtures.[13]

3.4.2 Tensile strength

Fig. 5. indicates to the effect of LDPE content on LDPE/aPP blends we show the tensile strength decreases from (12-6 MPa) with increasing of LDPE content from (10-50%) w%, this is because the 180o injection temperature leads to curing of the blends and trans the behavior from rubbery to brittle and stiff state. [14]

3.4.3 Elongation to Break:

Fig. 6. Indicate to the PP20% blend has the highest elongation to break then it decreases with increasing of LDPE to 20% content due to the fact that a.PP has the rubbery property and it is curing with 180oC injection temperature which it leads to translate ductile to brittle behavior of blends while it increase with increasing of LDPE content because decreasing of hardness of blend [14]

3.5 Impact Strength:

Fig 7. shows the effect of blend ratio on impact strength of (LDPE : aPP) polymer blends, we show that there are decreasing in impact strength these value for LDPE (10%) when mixed with (90%) aPP, while it increases with increasing of weight percentage of LDPE at (20-50%) content . As known, the brittleness of polypropylene is related to the spherulitic morphology and the intrinsic tendency of PP for crazing followed by unstable craze growth and crack propagation under conditions of stress concentration and/or low temperatures proved by [15]. So the impact test results indicate that the LDPE dispersions in PP provide multiple sites for crazing and localized shear yielding as mechanisms for the impact energy dissipation [16].

5. Thermal properties

5.1 DSC curves:

Table 2. and Figs (8-12) show the thermal analysis of pure polymers with blends, we notice from these figs, there are multi Tg of each blend which summarized in table 2.

Sample LDPE:a.PP	Tc 1 °C Peak	Integral (1) J/g	Tc 2 °C Peak	Integral (2) J/g	Td °C peak
LDPE 100%	125.7	-40.4	-	-	224.9
PP 100%	156.7	-15	-	-	233.6
10:90	122.27	-21.9	156.3	-27.6	248
30:70	125	-12.22	158.3	-30.48	212
50:50	125.33	-47.05	156.93	-32.24	290

From table (2) we notice there are one Tc of pure LDPE and PP while there are two Tc of there blends. This suggests the presence of two crystal populations in the solid state and immiscible blend was produced from mix of polypropylene with low density poly ethylene. Blends of a. PP/ LDPE and PP/LDPE3 containing 90% 70%, and 50%, PP showed crystallization peaks at (122 - 125) ºC and (156-158) ºC, respectively , Thus this peak can be attributed to the presence of branching since it is absent in the PP-rich region where LDPE is the minor component, also Although, Dong et al.[17] had attributed this observation to the presence of a different crystallization process in the PP. Hence, thermal analysis suggests the presence of multiple crystal populations in both blend systems and the appearance of such new peaks suggest a careful investigation of the crystal type and crystallization kinetics of PP/LDPE blends. Also we notice from previous figures the thermal degradation temperature of pure LDPE and PP is lower than there blends, this is refers to improvement of there thermal properties after blended. [18]

In addition, we notice there are an degraded was happened over (200 ºC) and the form of the curve refers to an degradation with cross linking happened through blends prepared.

5.2 Melt flow index

Table 3. Show the melt flow index of optimum samples: (3) and (4)

No. of sample	Samples	M.F.I g/10 min
1	LDPE 100%	10
2	PP 100%	8
3	30 LDPE : 70 a.PP	5.04
4	50 LDPE : 50 a.PP	4.02

We notice from table 3 there are an decreasing in melt flow index with increasing of LDPE content, this is because there are an cross linking between the polymeric chain was happened through the curing of LDPE:PP blends as proven by DSC analysis.[19]

6. Weight Gain:

Figs (13 and 14) show the weight gain of (30LDPE:70 a.PP) and (50LDPE:50 a.PP) respectively after immersion in three liquids (HCL as an acid media, NaOH as an base media , and water) for 5 week , we notice from these figs, there are an decreasing in weight of samples after once week , this is refers to an chemical degradation in sample was happened and some bonds were broken, after that , (2 week – 5 week) immersion time , there are an increasing in weight of samples was happened, this is because the degradation was stopped, and an swelling in polymer chain was happened.[20]

7. Conclusions:

1- Injection temperature plays an important role in blends properties, which leads to translate the mechanical behavior from state to other as in aPP which it become brittle at 180 ºC.

2- Adding of LDPE leads to improvement of mechanical properties (impact strength and bending modulus) at 50% content and Young's modulus at (10-30)% content, this is very important in practical application.

3- Thermal analysis of blends show the temperature of degradation of (50:50)wt% of (LDPE : aPP) is the highest, this is refers to increase of thermal resistance of blend.

4- An cross-linking of polymer chains of blends were happened and leads to decrease of the melt flow index of blends.

5- The best application of these blends is using as container of some chemical materials such as acids and basics with light concentrations also using at some applications, which need to high impact strength.

CONFLICT OF INTERESTS.

There are no conflicts of interest

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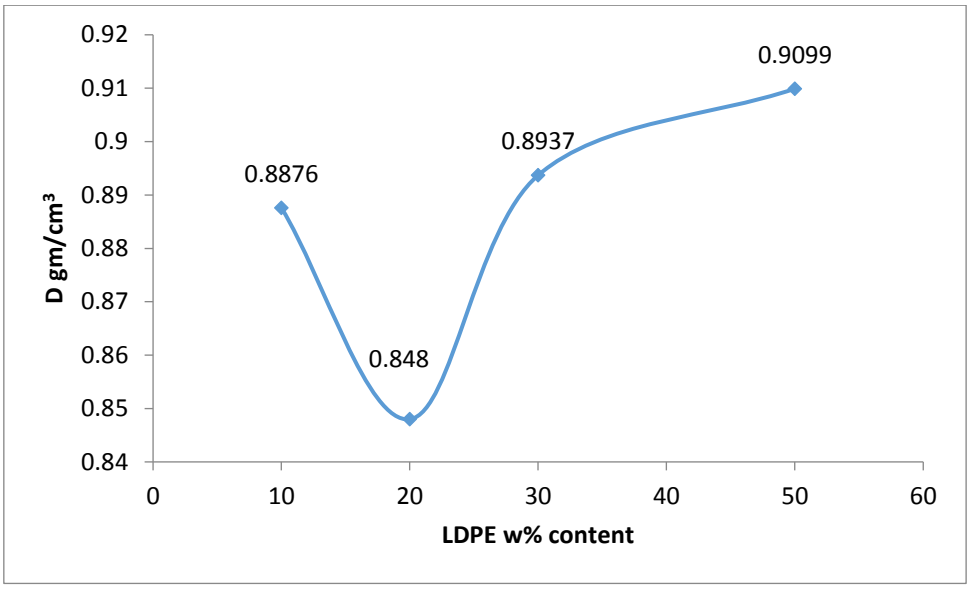

Fig 1. The density of blends and the content of LDPE in blends LDPE/APP

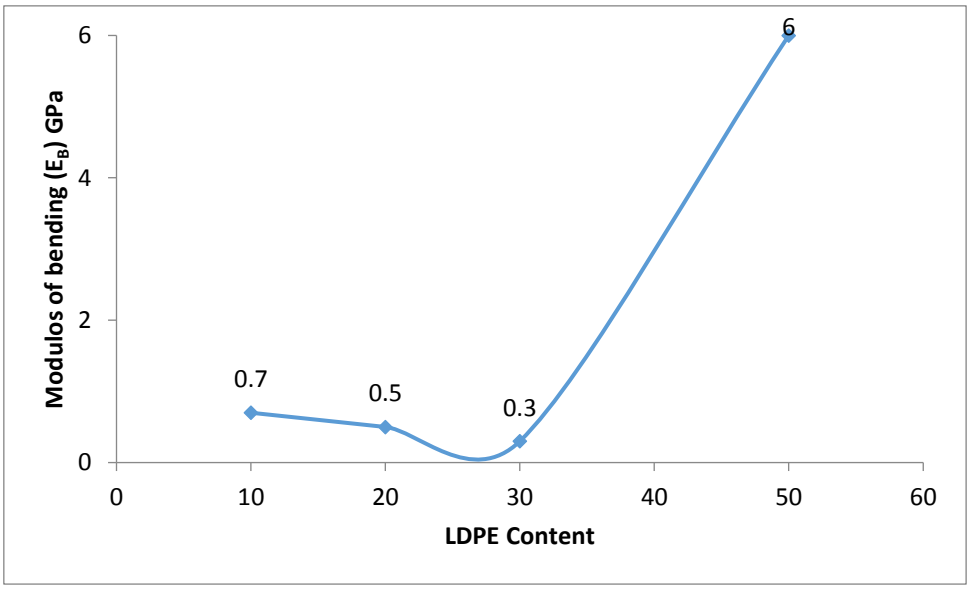

Fig 2. The effect of LDPE content on bending modulus of blends (LDPEaPP)

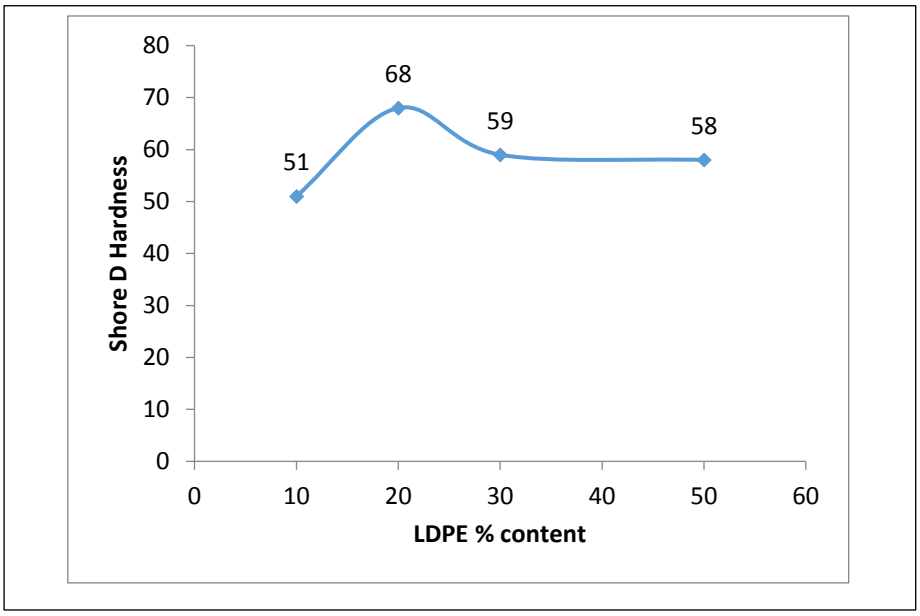

Fig. 3 The relationship between the Shore D Hardness and LDPE content in LDPE/aPP blends

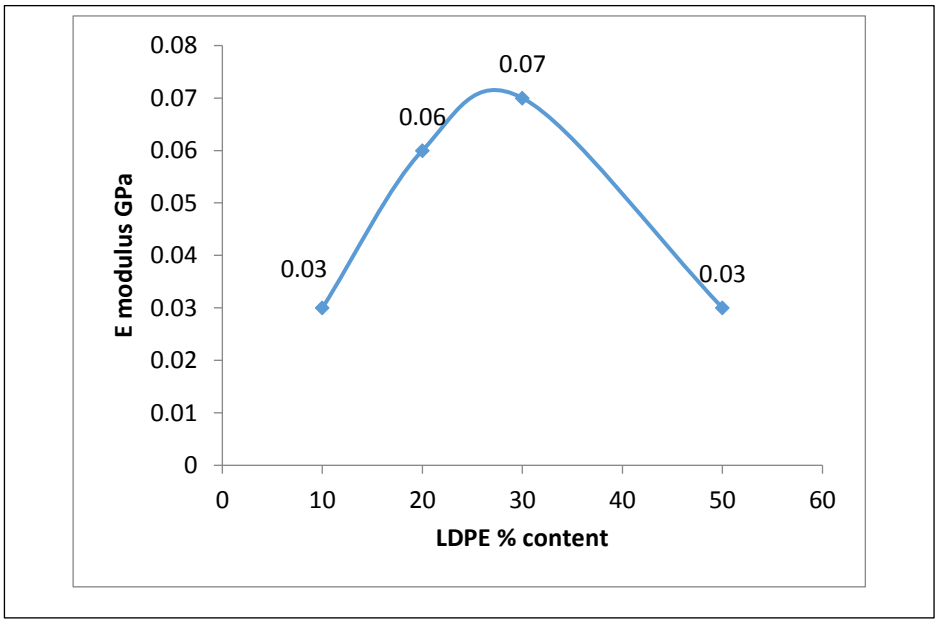

Fig. 4 The relationship between the Young's modulus of blends and the content of LDPE in LDPE/aPP blends

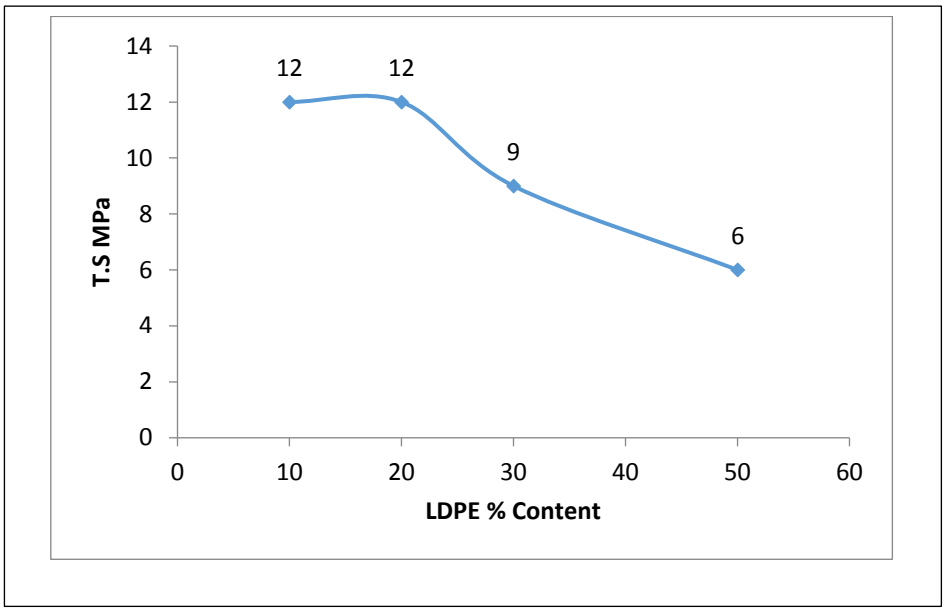

Fig 5. The relationship between the Tensile strength and LDPE content in LDPE/aPP blends

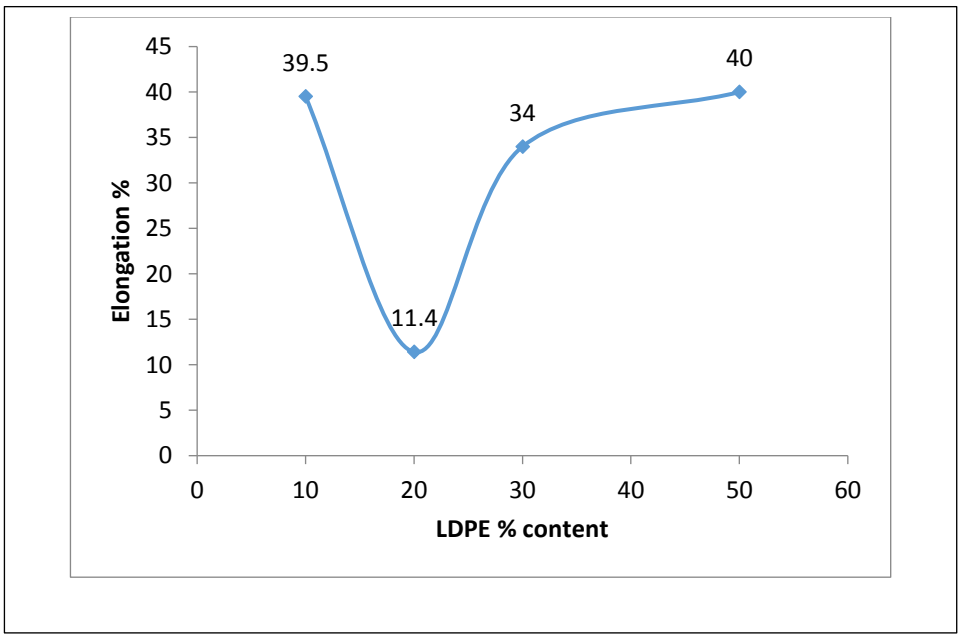

Fig. 6 The relationship between the Total percentage elongation Δl (%) and the content of LDPE in LDPE/APP blends

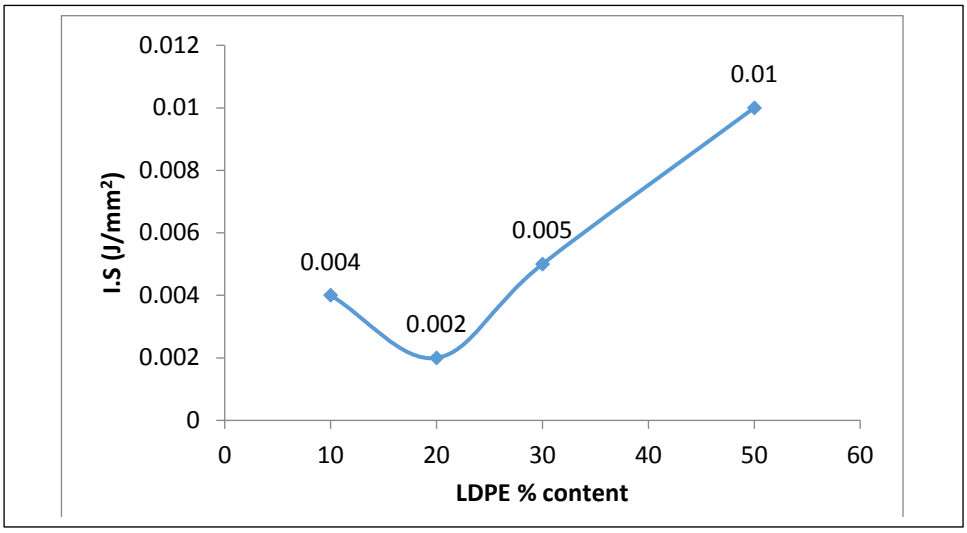

Fig. 7 The relationship between the Impact strength and LDPE content in LDPE/aPP blends

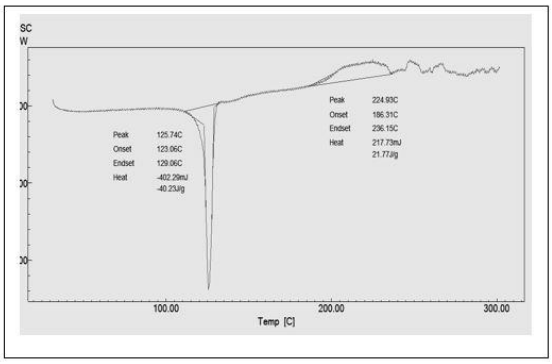

Fig (8) show the DSC curve of pure LDPE

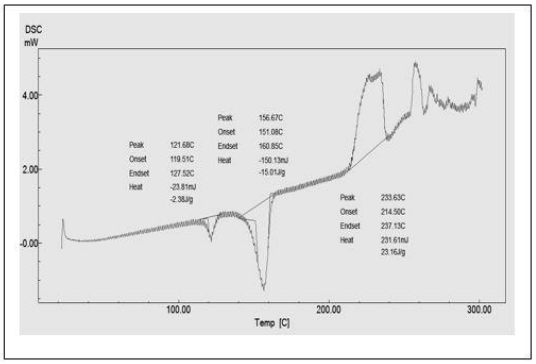

Fig (9) show the DSC curve of pure PP

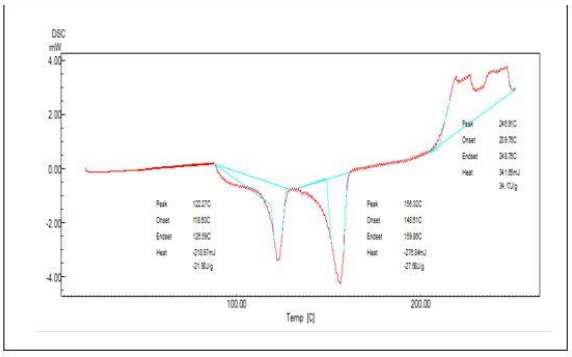

Fig (10) show the DSC curve of (10LDPE:90aPP)

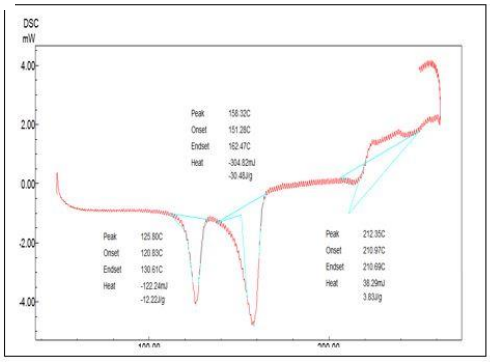

Fig 11. Show the DSC curve of (30LDPE:70 aPP)

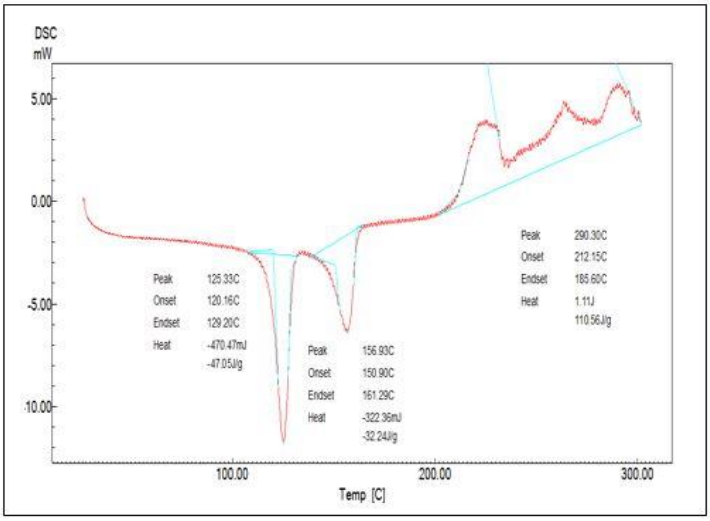

Fig 12. Show the DSC curve of (50 LDPE: 50 aPP)

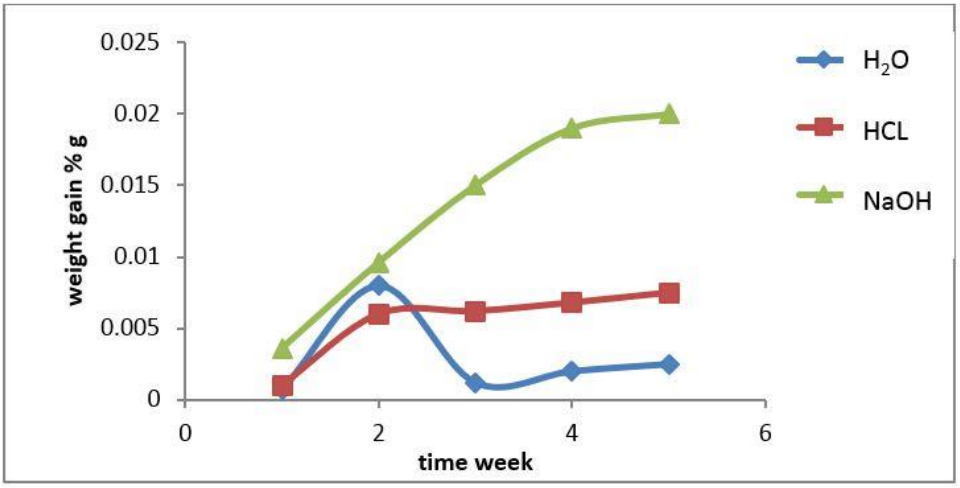

Fig 13. Weight gain of sample 3 (30LDPE:70 a.PP) after immersion in liquids (water, HCL, and NaOH) for 5 week

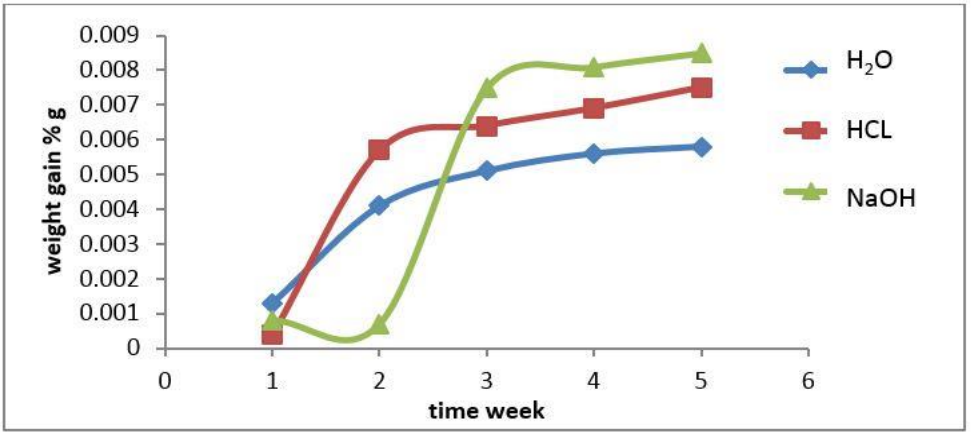

Fig 14. Weight gain of sample 4 (50LDPE:50 a.PP) after immersion in liquids (water, HCL, and NaOH) for 5 week

السلوك الفيزيائي لخليط البولي بروبلين العشوائي / البولي اثيلين الواطئ الكثافة تحت ظروف مختلفة

بلقيس محمد الدباغ

قسم العلوم التطبيقية، الجامعة التكنلوجية، بغداد-العراق

balkees1957@yahoo.com

هناء جواد كاظم

قسم هندسة البوليمر، كلية هندسة المواد، جامعة بابل، بابل-العراق

hanajawad21@yahoo.com

الخلاصه:

يهدف البحث الى تصنيع خليط بوليميري من البولي بروبلين العشوائي مضافا اليه البولي اثيلين الواطئ الكثافه لغرض تصنيع منتج اقتصادي وكذلك تحسين الخواص الميكانيكيه عند درجه بثق (180 ^{o} C) الخواص الميكانيكيه. (الكثافه، مقاومه الشد، الاستطاله عند الكسر، مقاومه الصدمه، مقاومه الانحناء، ومعامل المرونه

تم تحضير اربعه نماذج من خلائط بوليميريه من (البولي بروبلين: بولي اثيلين واطئ الكثافه) بنسب وزنيه (10/90, 20:80, 30:70, &50:50) بدرجه بثق (180 o C).

حيث تم ملاحظه ان السلوك الميكانيكي للخليط يعتمد على مكوناته وكذلك درجه البثق. اثبتت النتائج ان مقاومة الصدمه ومعامل الانحناء تزداد بزيادة النسبه الوزنيه للبولي اثيلين الواطئ الكثافه واعلى قيمه كانت عند نسبه وزنيه (50:50).

بينما اعلى قيمه لمعامل المرونه كانت عند النسبه (30:70) كما اثبتت النتائج ان درجه البثق تؤثر كثيرا في السلوك الميكانيكي للخليط حيث تعمل على تحويل السلوك من المطاطي الى السلوك الهش الجاسئ مما يؤثر على نتائج الخواص الميكانيكيه بشكل كبير.كما اثبتت نتائج التحليل الحراري بجهاز المسعر الحراري التفاضلي زياده درجات التبلور للخليط بزياده نسبه البولي اثيلين الواطئ الكثافه كما تشير الى زياده درجه حراره التفكك الحراري للخليط مما يزيد من المقاومه الحراريه الخليط .اما نتائج الانسياب الحراري فقد اثبتت نقصان معامل الانسياب للنموذج بزياده محتوى البولي اثيلين 30%الى 50%

الكلمات الداله:– خلائط غير متجانسة، خلائط بولي بروبليين/ بولي اثيلين واطئ الكثافة، الخواص الفيزيائية، بولي اثيلين واطئ الكثافة، بولي بروبلين، خلائط، خواص الصدمة والشد، الانثناء، كثافة الخلائط.